**Aurora Pooled Fund**

**RWIS Life Cycle Cost Analysis**

**Task 4 Technical Memorandum**

**Summary of RWIS DOT Survey**

# Introduction

This technical memorandum presents the information gathered from the RWIS DOT Survey. The purpose of the survey was to gather information from public agencies, including Aurora State DOT members, on costs, design service life, applicable warranties, recommendations regarding preventive maintenance, etc. as related to their RWIS systems. A separate survey was conducted concurrently to gather similar information from RWIS manufacturers. Upon collection and analysis of the results from both surveys, guidelines will be developed to provide a framework for estimating RWIS life cycle costs as well as supporting decisions on repair vs replacement/retirement of RWIS systems and components.

# DOT Survey

The RWIS DOT Survey asked public agencies various questions concerning their RWIS products, including:

* Number of RWIS stations deployed
* Number of years utilizing RWIS technology
* Procurement methods
* Brand(s)/manufacturer(s) of RWIS products
* General RWIS product information
* Information for each individual RWIS component, including:
* Air Temperature / Relative Humidity Sensor
* Surface Temperature Sensor
* Pavement Condition Sensor
* Wind Direction & Speed Sensor
* Precipitation Sensor
* Visibility Sensor
* Ultrasonic Snow Depth Sensor
* Subsurface Sensor
* Barometric Pressure Sensor
* Water Level Sensor
* Solar Radiation Kit
* Traffic/Vehicle Detection Sensor
* CCTV Camera (IP Surveillance System)
* Additional Sensor(s)
* The following information was inquired for each component:
* Product name/model
* Capital cost
* Average annual costs for preventative/routine maintenance
* Average number of times non-routine maintenance required per year
* Average non-routine maintenance cost per year
* Usefulness/importance
* Expected lifespan
* Product information for entire RWIS station(s):
* The following information was inquired for each station:
* System name/model
* Capital/system cost
* Average annual costs for preventative/routine maintenance
* Average number of times non-routine maintenance required per year
* Average non-routine maintenance cost per year
* Usefulness/importance
* Expected lifespan
* Software product(s) used to store, manage, and/or analyze RWIS data
* Cost of the software/licensing cost of software
* Cost of data storage/number of years of data stored
* Average installation cost per site
* Types of communications used by RWIS to transfer data
* Monthly telecommunications cost per site
* Annual staffing costs associated w/ ongoing RWIS operations
* Does your agency purchase the warranty on RWIS components? Cost of warranty?
* Who performs preventative/routine maintenance on your RWIS?
* Who performs non-routine maintenance on your RWIS?
* Have winter maintenance costs been reduced due to data provided by your RWIS network?
* Agency sharing of document(s) relating to their RWIS
* Does your agency plan to install additional RWIS in the future?
* Number of additional RWIS station(s) your agency plans on installing in the next 5 years

The DOT survey was developed by AECOM and reviewed by the Project Committee before being distributed to various public agencies in September 2019. The survey was distributed to various agencies via the Snow and Ice listserv maintained by the University of Iowa, to which several winter maintenance agencies and professionals subscribe to as a means of sharing and gathering information on winter maintenance operations. This listserv included the Aurora member states, in addition to city, county and state agencies as well as international agencies.

A total of ten agencies responded to the survey. Provided in Table 1 are the ten responding agencies as well as their contact information.

Table . Public Agency and Contact Information

| **Agency** | **Name** | **Title** | **Phone** | **Email** |
| --- | --- | --- | --- | --- |
| **North Dakota DOT** | Travis Lutman | ITS Manager | 701-328-4274 | tlutman@nd.gov |
| **Minnesota DOT** | Jon Bjorkquist | Statewide RWIS Coordinator | 218-828-5722 | jon.bjorkquist@state.mn.us |
| **New Hampshire DOT** | Lee Savary | Communications Technician 1 | 603-271-1669 | Lee.Savary@dot.nh.gov |
| Susan Klasen | TSMO Administrator | 603-271-6862 | susan.klasen@dot.nh.gov |
| **Michigan DOT** | James Roath | Roadway Operations Engineer | 517-230-5361 | RoathJ1@michigan.gov |
| **British Columbia Ministry of Transportation and Infrastructure** | Simon Walker | Weather and Climate Specialist | 778-974-5376 | simon.walker@gov.bc.ca |
| **Alaska DOT & PF** | Lisa Idell-Sassi | ITS Coordinator | 907-465-8952 | lisa.idell-sassi@alaska.gov |
| **Utah DOT** | Jeff Williams |  | 801-887-3703 | JeffWilliams@utah.gov |
| **Pennsylvania DOT** | Vincent Mazzocchi | Roadway Programs Manager for Winter/Incident Management | 717-705-1439 | vmazzocchi@pa.gov |
| **Wisconsin DOT** | Mike Adams | RWIS Program Manager | 608-266-5004 | michael.adams@dot.wi.gov |
| **Iowa DOT** | Tina Greenfield | RWIS Coordinator | 515-233-7746 | Tina.Greenfield@iowadot.us |

# Survey Results

This section provides a comprehensive listing of the results from the RWIS DOT Survey, as well as a side-by-side comparison of all agency responses for each question.

## Number of RWIS Stations / Years Using RWIS

Table 2 presents information on the approximate number of RWIS stations per agency and the number of years using RWIS, provided by the agencies who responded to the survey.

Table . Number of RWIS Stations and Number of Years Using RWIS

| **Agency** | **Number of RWIS Stations** | **Number of Years Using RWIS** | **Additional Information** |
| --- | --- | --- | --- |
| **North Dakota DOT** | Less than 30 | 23 to 30 years |  |
| **Minnesota DOT** | 101 to 150 | 23 to 30 years |  |
| **New Hampshire DOT** | Less than 30 | 7 to 14 years |  |
| **British Columbia Ministry of Transportation and Infrastructure** | 61 to 100 | 23 to 30 years |  |
| **Alaska DOT & PF**  | 61 to 100 | 15 to 22 years |  |
| **Utah DOT** | 101 to 150 | More than 30 years | Our RWIS data is critical for our UDOT Snow and Ice Performance Measure. Our instrumentation remains greater than 95% up time as a result. We have nearly 1500 RWIS instrumentation deployed. We will soon be deploying stand-alone road/visibility sensors only where an existing RWIS site is in the vicinity. |
| **Pennsylvania DOT** | 61 to 100 | Less than 7 years | PennDOT's goal with RWIS is to optimize geographic coverage and employ data to measure operational performance and drive improvements. |
| **Wisconsin DOT** | 61 to 100 | More than 30 years |  |
| **Iowa DOT** | 61 to 100 | More than 30 years | We may be moving to smaller, 'mini' sites in the future as our network gets denser. |

## Procurement Methods

Table 3 presents information on the methods used to procure RWIS products by survey respondents.

Table . Procurement Methods

| **Agency** | **Request for Proposals** | **Invitation for Bids** | **Additional Information** |
| --- | --- | --- | --- |
| **North Dakota DOT** |  | X | We bid the RWIS projects the same way we bid all construction projects. |
| **Minnesota DOT** |  | X | MnDOT has two RWIS vendors (Hoosier & Vaisala) on state contract. |
| **New Hampshire DOT** | X | X |  |
| **British Columbia Ministry of Transportation and Infrastructure** |  |  | Design, build, maintain our own stations in-house. Purchase equipment from various vendors. |
| **Alaska DOT & PF**  |  | X |  |
| **Utah DOT** |  |  | We have 5-year contract with instrumentation vendors and a separate contract for RWIS maintenance and installation. |
| **Pennsylvania DOT** | X |  |  |
| **Wisconsin DOT** | X |  |  |
| **Iowa DOT** | X |  |  |

## General RWIS Manufacturer / Product Information

Tables 4 and 5 present information on the RWIS products owned by survey respondents.

Table . RWIS Manufacturers by Agencies

| **Agency** | **Vaisala** | **Lufft (Hoosier)** | **Campbell Scientific** | **Boschung** | **High Sierra** | **Additional Information** |
| --- | --- | --- | --- | --- | --- | --- |
| **North Dakota DOT** | X | X |  | X |  |  |
| **Minnesota DOT** | X | X |  |  |  |  |
| **New Hampshire DOT** | X | X |  |  |  |  |
| **British Columbia Ministry of Transportation and Infrastructure** |  |  |  |  |  | No sole manufacturer/vendor(we design, build, & maintain our own stations in-house). |
| **Alaska DOT & PF**  | X |  | X |  |  |  |
| **Utah DOT** | X |  | X | X | X |  |
| **Pennsylvania DOT** | X |  |  |  |  |  |
| **Wisconsin DOT** |  | X |  |  |  |  |
| **Iowa DOT** | X | X |  |  |  |  |

Table . General RWIS Product Information

| **Agency** | **RWIS Manufacturers** | **RWIS Products** |
| --- | --- | --- |
| **Alaska DOT & PF** | Vaisala, Campbell Scientific | We use Novalynx Tipping Buckets, RM Young Anemometers, Windscreens, MRC Temperature Data Probes, Judd Snow Depth Sensors.Cameras by WTI, Axis, and Mobotix. |
| **British Columbia Ministry of Transportation and Infrastructure** | No sole manufacturer/vendor (we design, build, & maintain our own stations in-house). | Campbell Scientific CR1000 dataloggers, Vaisala DST/DSC pavement sensors, various other instrumentation. |
| **Minnesota DOT** | Vaisala, Lufft (Hoosier) | AXIS Q6125-LE PTZ network camera, Glen Martin Tower, Great Plains Tower, RM Young 05103 WindLufft (Hoosier): LCOM RPU, WS100 UMB precipitation, VS2K visibilityVaisala: RWS110 LX RPU, RWS200 RPU, HMP155 air temp/relative humidity, PWD22 precipitation/visibility, PTB110 barometer |
| **New Hampshire DOT** | Original stations were SSI (Subsurface Systems Inc.), now Vaisala; Lufft (Hoosier) | Vaisala LX (21), Vaisala RWS200 (1), Lufft LCOM/UMB (3); Various brands of Vaisala sensors |
| **North Dakota DOT** | Lufft (Hoosier)(we do have several Vaisala sites and one Boschung site for our FAST) | A typical Lufft site has the following sensors: Axis Q6055-E Camera, IR illuminator, LCOM, NIRS-31 sensor, WS100, WS301, WS200, and 72" deep subsurface probe. |
| **Pennsylvania DOT** | Vaisala | RWS200 and associated components |
| **Utah DOT** | Vaisala, Campbell Scientific, High Sierra, Boschung | We have too many products to list. We customize our instrumentation to our specific needs and requirements. Essentially, we design our own RWIS system. |
| **Wisconsin DOT** | Manufacturer: Lufft (Hoosier) | WisDOT has 20 Lufft sites and 50 legacy Vaisala sites.Lufft sites have the LCOM RPU, IRS 31 pavement sensors, subsurface probe, OWI-430 precipitation sensor, Young 41382 temp/relative humidity sensor, and Young 05103 wind sensor.Vaisala sites have FP2000 pavement sensors and a variety of atmospheric sensors. |
| **Iowa DOT** | Ours is a mix of vendors. Most of our RPUs are Vaisala LX but we also have a number of Lufft LCOMs. | We have a wide variety of sensors.Vaisala, RM Young, OSI, Lufft, Thies Clima, Axis cameras, Wavetronix traffic sensors. |

## Air Temperature / Relative Humidity Sensors

Table 6 presents the information on Air Temperature/Relative Humidity Sensors provided by survey respondents.

Table . Air Temperature/Relative Humidity Sensor

| **Agency** | **Product Name and Model** | **Capital Cost** | **Average Annual Costs for Preventive/Routine Maintenance** | **Average Number of Times Non-Routine Maintenance Required per Year** | **Average Non-Routine Maintenance Cost per Year** | **Usefulness/Importance (1-5, 5 = most important)** | **Expected Lifespan** | **Additional Information** |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Alaska DOT & PF** | Vaisala HMP155 | $2,420 |  |  |  | 5 | 9 to 11 years | We are starting to install the HMP155 when the Thies die. So, I don't have a whole lot of data with the HMP155 yet |
| **New Hampshire DOT** |  | $3,000 | 100 | 0 |  | 5 | 9 to 11 years | Relatively few problems with these sensors |
| **Utah DOT** |  | $422 | $185 per entire RWIS site per year. Unknown on an instrumentation level. | Estimate 50 RWIS sites require response maintenance. Unknown on an instrumentation level. | $435 per entire RWIS site per year. Unknown on an instrumentation level. | 4 | 9 to 11 years |  |
| **Wisconsin DOT** |  | $1,005 | Unknown | 0.5 | Unknown | 4 | 6 to 8 years |  |
| **Iowa DOT** |  | $800 | Bundled with the rest of our maintenance | Of a network of 72, about 7-8 go bad each year | Bundled | 3 | 6 to 8 years | Similar for Thies, RM Young, and Vaisala version of this sensor.The radiation shields/brackets can sometimes be reused. |

## Surface Temperature Sensors

Table 7 presents the information on Surface Temperature Sensors provided by survey respondents.

Table . Surface Temperature Sensor

| **Agency** | **Product Name and Model** | **Capital Cost** | **Average Annual Costs for Preventive/Routine Maintenance** | **Average Number of Times Non-Routine Maintenance Required per Year** | **Average Non-Routine Maintenance Cost per Year** | **Usefulness/Importance****(1-5, 5 = most important)** | **Expected Lifespan** | **Additional Information** |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Utah DOT** |  | $4,036 | Unknown on an instrumentation level. | Unknown on an instrumentation level. | Unknown on an instrumentation level. | 4 | 9 to 11 years | We also use 2 other sensors. High Sierra Sentintel ($1,525), High Sierra Icesight road temp/condition combo ($11,575) |
| **Alaska DOT & PF****(2 products)** |  | $896 - $4,642 |  |  |  | 5 | 6 to 8 years | Non-invasive pavement temp sensor.Lifespan is dependent on whether a road project mills up the sensor |
| **Wisconsin DOT** **(2 products)** |  | $5,000 - $5,866 | Unknown | 0.25 - 0.5 | Unknown | 5 | 3 to 11 years | Lufft sensors seem less reliable than FP2000 |
| **Iowa DOT** |  | $3,451 each, plus install | Bundled with contract | 200+ sensors, we have at least 12-15 that need to be replaced each year | Average around $6,000 for each one that needs to be replaced (sensor + labor) | 5 | 6 to 8 years | Majority all FP2000. A few Lufft.Construction/maintenance kills a lot. Their natural life span is probably much longer. |

## Pavement Condition Sensors

Table 8 presents the information on Pavement Condition Sensors provided by survey respondents.

Table . Pavement Condition Sensor

| **Agency** | **Product Name and Model** | **Capital Cost** | **Average Annual Costs for Preventive/Routine Maintenance** | **Average Number of Times Non-Routine Maintenance Required per Year** | **Average Non-Routine Maintenance Cost per Year** | **Usefulness/Importance****(1-5, 5 = most important)** | **Expected Lifespan** | **Additional Information** |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Utah DOT** |  | $9,995 | Unknown on an instrumentation level. | Unknown on an instrumentation level. | Unknown on an instrumentation level. | 5 | 9 to 11 years |  |
| High Sierra Icesight | $11,575  | Unknown on an instrumentation level. |  | Unknown on an instrumentation level. | 5 | 3 to 7+ years |  |
| **Alaska DOT & PF** | Vaisala DSC111 | $12,722  |  |  |  | 4 | 6 to 8 years | Non-invasive;Too early to tell what their lifespan will be.In addition to the DTS210, our pavement sensors include the FP2000 which I do not have costs. |
| **Iowa DOT** |  | $16,565 | Bundled |  | Bundled | 4 | 6 to 8 years | We only have a few of these sensors.Based on one failed sensor. The rest are too new to tell. |

## Wind Direction & Speed Sensors

Table 9 presents the information on Wind Direction/Speed Sensors provided by survey respondents.

Table . Wind Direction/Speed Sensor

| **Agency** | **Product Name and Model** | **Capital Cost** | **Average Annual Costs for Preventive/Routine Maintenance** | **Average Number of Times Non-Routine Maintenance Required per Year** | **Average Non-Routine Maintenance Cost per Year** | **Usefulness/Importance****(1-5, 5 = most important)** | **Expected Lifespan** | **Additional Information** |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Alaska DOT & PF** | RM Young 05103 | $1,240 |  |  |  | 5 | 6 to 8 years |  |
| RM Young 05106 | $1,482 |  |  |  | 5 | 6 to 8 years |  |
| Vaisala WMT700 Ultrasonic Heated | $2,807 |  |  |  | 5 | 6 to 8 years |  |
| **Utah DOT** | Standard wind sensor(Brand/model unknown) | $1,093 | Unknown on an instrumentation level. | Unknown on an instrumentation level. | Unknown on an instrumentation level. | 4 | 9 to 11 years | We use alpine version in areas of high ice riming. |
| Alpine high-performance sensor(Brand/model unknown) | $2,131 | Unknown on an instrumentation level. | Unknown on an instrumentation level. | Unknown on an instrumentation level. | 4 | 9 to 11 years |  |
| **Wisconsin DOT** |  | $1,183 | Unknown | 1 | Unknown | 3 | 9 to 11 years |  |
| **Iowa DOT** |  | $1,107 | Bundled | At least 4 in our network of 70-ish sites with anemometers | Bundled | 4 | 6 to 8 years | Similar for RM Young or Vaisala brands.Bearings are replaced through regular maintenance. |

## Precipitation Sensors

Table 10 presents the information on Precipitation Sensors provided by survey respondents.

Table . Precipitation Sensor

| **Agency** | **Product Name and Model** | **Capital Cost** | **Average Annual Costs for Preventive/Routine Maintenance** | **Average Number of Times Non-Routine Maintenance Required per Year** | **Average Non-Routine Maintenance Cost per Year** | **Usefulness/Importance****(1-5, 5 = most important)** | **Expected Lifespan** | **Additional Information** |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Utah DOT** | Novalynx Tipping Rain Bucket | $382 | Unknown on an instrumentation level. | Unknown on an instrumentation level. | Unknown on an instrumentation level. | 5 | 9 to 11 years | Rain buckets are very useful for alerting for potential debris flows |
| **Alaska DOT & PF** | Texas Electronic 525 | $1,711 |  |  |  |  |  |  |
| Vaisala DRD11A | $1,178 |  |  |  | 5 | 9 to 11 years | This model is replacing all of our Hawkeyes |
| Novalynx 260-2500E | $768 |  |  |  |  |  |  |
| **Iowa DOT** | Lufft R2S | $4,474 | Bundled | 4? | Bundled | 4 | 6 to 8 years | This is just for our Lufft R2S version. |
| OSI WIVIS | $7,480 | Bundled | At least 10 |  | 4 | 6 to 8 years | This is for our OSI WIVIS, and Vaisala PWD12s.The life is long, but sometimes they need maintenance/parts in the interim. |
| Vaisala PWD12 | $7,480 | Bundled | At least 10 |  | 4 | 6 to 8 years |  |

## Visibility Sensors

Table 11 presents the information on Visibility Sensors provided by survey respondents.

Table . Visibility Sensor

| **Agency** | **Product Name and Model** | **Capital Cost** | **Average Annual Costs for Preventive/Routine Maintenance** | **Average Number of Times Non-Routine Maintenance Required per Year** | **Average Non-Routine Maintenance Cost per Year** | **Usefulness/Importance****(1-5, 5 = most important)** | **Expected Lifespan** | **Additional Information** |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Alaska DOT & PF** | Vaisala PWD12 | $7,089 |  |  |  |  | 6 to 8 years |  |
| Vaisala PWD22 | $10,378 |  |  |  | 5 | 6 to 8 years | We are hoping the PWD's last longer but we won't know for a few more years |
| **Utah DOT** | Campbell CS125 | $4,350  | Unknown on an instrumentation level. | Unknown on an instrumentation level. | Unknown on an instrumentation level. | 5 | 9 to 11 years | We also use this sensor for estimating snowfall rates for our performance measure. |
| **Wisconsin DOT** |  | $8,160 | Unknown | 1.5 | Unknown | 4 | 3 to 5 years |  |
| **Iowa DOT** |  | $7,480 | Bundled | At least 10 |  | 3. More if they'd work more reliably | 6 to 8 years | Phasing these out because they're maintenance intensive.Similar for OSI or Vaisala. |

## Ultrasonic Snow Depth Sensors

Table 12 presents the information on Ultrasonic Snow Depth Sensors provided by survey respondents.

Table . Ultrasonic Snow Depth Sensor

| **Agency** | **Product Name and Model** | **Capital Cost** | **Average Annual Costs for Preventive/Routine Maintenance** | **Average Number of Times Non-Routine Maintenance Required per Year** | **Average Non-Routine Maintenance Cost per Year** | **Usefulness/Importance****(1-5, 5 = most important)** | **Expected Lifespan** | **Additional Information** |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Alaska DOT & PF** | Judd Ultrasonic Snow Depth Sensor | $1,262 |  |  |  |  | 9 to 11 years |  |
| **Utah DOT** |  | $865 | Unknown on an instrumentation level. | Unknown on an instrumentation level. | Unknown on an instrumentation level. | 3 | 9 to 11 years | More useful for mountain locations, doesn't have the sensitivity needed for valleys. |

## Subsurface Sensors

Table 13 presents the information on Subsurface Sensors provided by survey respondents.

Table . Subsurface Sensor

| **Agency** | **Product Name and Model** | **Capital Cost** | **Average Annual Costs for Preventive/Routine Maintenance** | **Average Number of Times Non-Routine Maintenance Required per Year** | **Average Non-Routine Maintenance Cost per Year** | **Usefulness/Importance****(1-5, 5 = most important)** | **Expected Lifespan** | **Additional Information** |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Alaska DOT & PF** | Vaisala DTS210 | $896 |  |  |  |  | 6 to 8 years | Lifespan depends on whether or not there is roadwork that destroys the sensor. |
| **Utah DOT** | Soil temp sensor(Brand/model unknown) | $82 | Unknown on an instrumentation level. | Unknown on an instrumentation level. | Unknown on an instrumentation level. | 5 | 9 to 11 years | Critical for determining snowfall rate for road snow. Soil moisture for blowing dust. |
| Soil moisture sensor(Brand/model unknown) | $252 | Unknown on an instrumentation level. | Unknown on an instrumentation level. | Unknown on an instrumentation level. | 5 | 9 to 11 years | Critical for determining snowfall rate for road snow. |
| **Wisconsin DOT** |  | $688 | Unknown | 0 | 0 | 4 | 9 to 11 years |  |
| **Iowa DOT** |  | $629 | Bundled | 5 | About $2,000 per unit, more or less depending if they're doing a surface sensor too | 3 | 9 to 11 years | This is just the single-point version.Very long-lived and trouble free if it were not for road work taking them out. |
|  | $2,890 | Bundled | At least 2 times (for only 15 total in the state). | $5,000; more or less depending on if they're also doing a surface sensor | 3 | < 3 years | This is for the multi-array deep probe.These seem to require a lot of maintenance to keep going. |

## Barometric Pressure Sensors

Table 14 presents the information on Barometric Pressure Sensors provided by survey respondents.

Table . Barometric Pressure Sensor

| **Agency** | **Product Name and Model** | **Capital Cost** | **Average Annual Costs for Preventive/Routine Maintenance** | **Average Number of Times Non-Routine Maintenance Required per Year** | **Average Non-Routine Maintenance Cost per Year** | **Usefulness/Importance****(1-5, 5 = most important)** | **Expected Lifespan** | **Additional Information** |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Alaska DOT & PF** | Vaisala PTB110 | $998 |  |  |  |  | 9 to 11 years |  |

## Solar Radiation Kits

Table 15 presents the information on Solar Radiation Kits provided by survey respondents.

Table . Solar Radiation Kit

| **Agency** | **Product Name and Model** | **Capital Cost** | **Average Annual Costs for Preventive/Routine Maintenance** | **Average Number of Times Non-Routine Maintenance Required per Year** | **Average Non-Routine Maintenance Cost per Year** | **Usefulness/Importance****(1-5, 5 = most important)** | **Expected Lifespan** | **Additional Information** |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Utah DOT** |  | $515 | Unknown on an instrumentation level. | Unknown on an instrumentation level. | Unknown on an instrumentation level. | 2 | 9 to 11 years | Most useful in canyons |

## Traffic/Vehicle Detection Sensors

Table 16 presents the information on Traffic/Vehicle Detection Sensors provided by survey respondents.

Table . Traffic/Vehicle Detection Sensor

| **Agency** | **Product Name and Model** | **Capital Cost** | **Average Annual Costs for Preventive/Routine Maintenance** | **Average Number of Times Non-Routine Maintenance Required per Year** | **Average Non-Routine Maintenance Cost per Year** | **Usefulness/Importance****(1-5, 5 = most important)** | **Expected Lifespan** | **Additional Information** |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Iowa DOT** | Wavetronix HD | $7,875 | Bundled | 4 |  | 2 | 9 to 11 years | Generally fairly maintenance-free.Wavetronix HD. |

## CCTV Cameras

Table 17 presents the information on CCTV cameras provided by survey respondents.

Table . CCTV Camera

| **Agency** | **Product Name and Model** | **Capital Cost** | **Average Annual Costs for Preventive/Routine Maintenance** | **Average Number of Times Non-Routine Maintenance Required per Year** | **Average Non-Routine Maintenance Cost per Year** | **Usefulness/Importance****(1-5, 5 = most important)** | **Expected Lifespan** | **Additional Information** |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Utah DOT** | AXIS fixed-view camera | $899  | Unknown on an instrumentation level. | Unknown on an instrumentation level. | Unknown on an instrumentation level. | 5 | 3 to 5 years | Fixed view often has better night vision. |
| AXIS Q6125-LE PTZ | $2,276 | Unknown on an instrumentation level. | Unknown on an instrumentation level. | Unknown on an instrumentation level. | 5 | 3 to 5 years |  |
| **Alaska DOT & PF** | AXIS Q6114 | $3,373 |  |  |  | 5 | 6 to 8 years |  |
| AXIS Q6125-LE | $3,325 |  |  |  | 5 | 6 to 8 years | Lifespan to be determined |
| AXIS Q6055 PTZ | $3,709  | Unknown on an instrumentation level. | Unknown on an instrumentation level. | Unknown on an instrumentation level. | 5 | 6 to 8 years | Fixed view often has better night vision. |
| AXIS Q8685-LE PTZ | $7,280 |  |  |  | 5 | 6 to 8 years | Lifespan to be determined |
| WTI Viper | $3,940 |  |  |  | 5 | 6 to 8 years | Lifespan to be determined |
| **Iowa DOT** | AXIS PTZ Heated camera | $6,505 | Bundled | About once per year each |  | 4 | 6 to 8 years | Lots of visits, but not often the whole camera needs to be replaced; sometimes it's just a reset.Generally, the hardware is more reliable than the software. Needs lots of resets and lens cleanings/repair. Axis PTZ heated cameras. |

## Additional Sensors

Table 18 presents the information on any additional Sensors the agencies operate provided by survey respondents.

Table . Additional Sensors

| **Agency** | **Product Name and Model** | **Sensor Type** | **Capital Cost** | **Average Annual Costs for Preventive/Routine Maintenance** | **Average Number of Times Non-Routine Maintenance Required per Year** | **Average Non-Routine Maintenance Cost per Year** | **Usefulness/Importance****(1-5, 5 = most important)** | **Expected Lifespan** | **Additional Information** |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Alaska DOT & PF** | Vaisala TDP | Temperature Data Probe | $4,623 |  |  |  | 5 | 6 to 8 years |  |
| **Utah DOT** |  | Datalogger | $1,700 | Unknown on an instrumentation level. | Unknown on an instrumentation level. | Unknown on an instrumentation level. | 5 | > 11 years |  |

## Entire RWIS Station / System

Table 19 presents the information on entire RWIS systems provided by survey respondents.

Table . Entire RWIS System

| **Agency** | **System Brand/Model** | **Capital/System Cost** | **Average Annual Costs for Preventive/Routine Maintenance** | **Average Number of Times Non-Routine Maintenance Required per year** | **Average Non-Routine Maintenance Cost per Year** | **Usefulness/Importance****(1-5, 5 = most important)** | **Expected Lifespan** | **Additional Information** |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Alaska DOT & PF** | Campbell Scientific | $12,579 | $1,778 | 2 |  | 5 | 9 to 11 years | Not all equipment here is CSI.My site costs are for equipment only. They don't include installation costs. |
| Vaisala | $32,600 |  | 1-2 | $1,846 | 5 | > 11 years |  |
| **North Dakota DOT** | Lufft | $130,000 | We don't track these costs but they are pretty low | A couple times per year | We don't track this | 4 | > 11 years | Our staff maintains and repairs our sites. We don't have a good way of tracking all work that is done at each site. Each District replaces sensors during the life of the site so we don't have a good way to track their replacement either. |
| **Wisconsin DOT** | Lufft LCOM | $53,550 | $3,000 | 50 | Unknown | 5 | > 11 years |  |
| Vaisala ESP RPU | $35,000 | $3,000 | 50 | Unknown | 5 | > 11 years |  |
| **Pennsylvania DOT** | Vaisala RWS200 | $50,000 - $65,000 | ~$6,000(per site, per year) | N/A(performance-based preventative maintenance contract only) | N/A | 5 | > 11 years | Routine PM payment is based on monthly performance of the system, and monthly payment is reduced on a per-site basis. Over the full contract term, performance penalty became less as new sites were added to the system, while annual per-site costs also decreased. |
| **Utah DOT** | Custom | $25,000 - $50,000(per RWIS install) | $24,657 | 50 | $57,902 | 5 | 9 to 11 years | We also have an end of life replacement program, 10-year lifespan for most instruments, less for cameras and lead acid batteries. |
| **Iowa DOT** | Our entire stations are mixes of brands. Mostly Vaisala LX processors | $70,000 per install | Bundled with all the rest of our ITS equipment. Probably around $110,000 | See info on sensors. Each one is different. Otherwise, power, communications, and tower issues need 1 visit per site per year |  | 5 | > 11 years | Individual components don't last that long but we have some sites that are 30 years old. |

## Software Products and Costs

Table 20 presents the general product and cost information for RWIS software provided by the survey respondents.

Table . RWIS Software

| **Agency** | **Software Products Used** | **Software Cost/Software Licensing Cost** |
| --- | --- | --- |
| **North Dakota DOT** | Parsons ATMS - Used for RWIS, DMS, and Cameras. | $450,000 in 2014, including 3 years of maintenance starting from install completion.$70,000/year for maintenance and upgrade fee after 3 years. |
| **Alaska DOT & PF**  | Vaisala's ScanWeb. We are in the process of migrating to the MNDOT IRIS software. | N/A |
| **Utah DOT** | Campbell Loggernet, and server services. Custom software to store, manage and analyze. | One-time cost many years ago. Would take some work to dig that up. |
| **Pennsylvania DOT** | Vaisala RoadDSS Navigator | Included with web hosting and data services contract requirement, total of $108,000/year |
| **Wisconsin DOT** | SCAN Web, Lufft | Currently no cost |
| **Iowa DOT** | Was ScanWeb. Now have switched to DTN Totalview. | ScanWeb was $25,000 for the license, putting it on our own servers. Totalview is $54,000 per year. |

## Data Storage Cost / Number of Years of Data Stored

Table 21 presents the information on storage costs and years of data stored for RWIS data provided by the survey respondents.

Table . RWIS Data Storage Cost/Years of Data Stored

| **Agency** | **Data Storage Cost/Years of Data Stored** |
| --- | --- |
| **North Dakota DOT** | We store all RWIS data and only 24 hours of camera images. This is stored at NDIT and is included in our server fee. |
| **Alaska DOT & PF**  | N/A |
| **Utah DOT** | Unknown. We store infinite amount of RWIS data. 3 years’ worth of specified RWIS camera snapshots. |
| **Pennsylvania DOT** | Included with web hosting and data services contract requirement, total of $108,000/year. No limit to data storage during contract terms. |
| **Wisconsin DOT** | SCAN Web has no archive and Lufft has about 7 years. |
| **Iowa DOT** | DTN has 3 years, ScanWeb has 15 years. Not priced by storage. |

## Average Installation Cost

Table 22 presents the information on average cost of installation for RWIS sites provided by the survey respondents.

Table . RWIS Site Installation Cost

| **Agency** | **Avg. Installation Cost per Site** |
| --- | --- |
| **North Dakota DOT** | $130,000  |
| **Alaska DOT & PF**  | $100,000  |
| **Utah DOT** | $25,000 - $50,000 |
| **Pennsylvania DOT** | Contract price ~$55,000/site |
| **Wisconsin DOT** | $53,550  |
| **Iowa DOT** | $70,000 |

## Types and Costs of Communications

Table 23 presents the type and cost information for RWIS communications provided by the survey respondents.

Table . RWIS Communications Type/Cost

| **Agency** | **Fiber Optic** | **Cellular** | **Radio** | **Other****(Please specify)** | **Monthly Telecommunications Cost per Site** |
| --- | --- | --- | --- | --- | --- |
| **North Dakota DOT** | X | X |  | Most of our sites are on cellular but we do have a couple that are on fiber. | Cellular is $40/month.Fiber is on our own network and is $1,000/month for the link and $30/month to each end point. |
| **Alaska DOT & PF**  | X | X |  | Satellite | $30 - $112 |
| **Utah DOT** | X | X |  |  | Cell: $20 - $30/monthUDOT fiber: $0/month |
| **Pennsylvania DOT** |  | X |  |  | Included with web hosting and data services contract requirement, all services $9,000/month. |
| **Wisconsin DOT** |  | X |  | Landline | $35  |
| **Iowa DOT** | X | X |  | DSL | Cellular is ~$15/month.DSL can be as much as $70/month. |

## Annual Staffing Costs for RWIS Operations

Table 24 presents the information on annual staffing costs for ongoing RWIS operations provided by the survey respondents.

Table . RWIS Operations Staffing Cost

| **Agency** | **Annual Staffing Costs for RWIS Operations** |
| --- | --- |
| **North Dakota DOT** | We do not track this but we have one ITS Manager and essentially 10 technicians that take care of our ITS devices. |
| **Alaska DOT & PF**  | We have a contractor who maintains all sites. Those costs are included in the estimated per site costs provided earlier. |
| **Utah DOT** | Very difficult to answer. Staff performs multiple functions that could be non-RWIS related. |
| **Pennsylvania DOT** | No internal staffing costs are directly associated with operations of RWIS. |
| **Wisconsin DOT** | $5,000  |
| **Iowa DOT** | Nobody dedicates a full FTE to RWIS. Most maintenance is contracted out as previously described. Otherwise it is just a part of a few people's workload. |

## Warranty for RWIS Components

Table 25 presents the information on whether agencies purchase a warranty and warranty costs for their RWIS components provided by the survey respondents.

Table . RWIS Warranty Purchase/Cost

| **Agency** | **Warranty Purchase?****(Yes/No)** | **Cost of Warranty/Other Comments** |
| --- | --- | --- |
| **North Dakota DOT** | Yes | We require a 3-year warranty at the time of purchase. |
| **Alaska DOT & PF**  | No |  |
| **Utah DOT** | Yes | Our 5-year RWIS parts contract has a 2-year warranty built into the contract. |
| **Pennsylvania DOT** | No | Warranty purchased separately. All components covered by performance-based maintenance contract. |
| **Wisconsin DOT** | Yes | Unknown |
| **Iowa DOT** | No |  |

## Preventative / Routine RWIS System Maintenance

Table 26 presents the information on institutions responsible for performing preventative and routine maintenance on RWIS equipment provided by the survey respondents.

Table . Responsible Organization for Preventative/Routine Maintenance

| **Agency** | **RWIS Vendor** | **Contracted Services** | **Agency Force** |
| --- | --- | --- | --- |
| **North Dakota DOT** |  |  | X |
| **Alaska DOT & PF**  | X | X |  |
| **Utah DOT** |  | X |  |
| **Pennsylvania DOT** | X |  |  |
| **Wisconsin DOT** |  | X |  |
| **Iowa DOT** |  | X |  |

## Non-Routine RWIS System Maintenance

Table 27 presents the information on institutions responsible for performing non-routine maintenance and repair on RWIS equipment provided by the survey respondents.

Table . Responsible Organization for Non-Routine Maintenance/Repair

| **Agency** | **RWIS Vendor** | **Contracted Services** | **Agency Force** |
| --- | --- | --- | --- |
| **North Dakota DOT** |  |  | X |
| **Alaska DOT & PF**  | X | X |  |
| **Utah DOT** |  | X |  |
| **Pennsylvania DOT** | X |  |  |
| **Wisconsin DOT** |  | X |  |
| **Iowa DOT** |  | X |  |

## Reduction of Winter Maintenance Costs due to RWIS Data

Table 28 presents the information on whether survey respondents believe a reduction in winter maintenance costs due to RWIS data has occurred.

Table . Winter Maintenance Cost Reduction due to RWIS Data

| **Agency** | **Yes** | **No** |
| --- | --- | --- |
| **North Dakota DOT** | X |  |
| **Alaska DOT & PF**  | X |  |
| **Utah DOT** | X |  |
| **Pennsylvania DOT** | X |  |
| **Wisconsin DOT** | X |  |
| **Iowa DOT** | X |  |

## Future RWIS Installations

Table 29 presents the information on the timeframes of future RWIS installations and the number of RWIS planned to be installed within the next five years.

Table . Additional RWIS Installations

| **Agency** | **Additional RWIS Installation Timeframe** | **Number of Additional RWIS Planned within Next 5 Years** |
| --- | --- | --- |
| **North Dakota DOT** | Within next 3 years | Our plan is to get to 60 RWIS, so we plan to install another 31 in the coming years. |
| **Alaska DOT & PF**  | Within next 3 years | 5 to 8 |
| **Utah DOT** | Within next 3 years | We are currently installing about 20+ RWIS sites per year and will continue to do so for several years to support our Snow and Ice Performance Measure. |
| **Pennsylvania DOT** | Within next 3 years | 5 to 10 |
| **Wisconsin DOT** | Within next 3 years | 10  |
| **Iowa DOT** | Within next 3 years | About 3 |